Ecosystem Management: Facts, Fiction, or Fantasy

And Something About Menhaden

Source: Chesapeake Bay Program

James E. Kirkley

College of William and Mary

Virginia Institute of Marine Science

School of Marine Science

Gloucester Point, VA 23062

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Topics of Discussion

- **Question of Fact, Fiction, or Fantasy relative to ecosystem management—Quick Answer—fact, it is here, and it is being done in numerous nations**
- **What is ecosystem management from the perspective of one economist?**
- **What is the potential role of economics for ecosystem management?**
- **Despite the limitations, uncertainties, and unknowns associated with ecosystem management, economics can still offer valuable information for ecosystem-based management**

- **The meatier part—ecosystem management and menhaden**

Photographer: Bob Williams

Ecosystem Management and Economics

Just as the term is interpreted by scientists to mean many different things, it also implies many different things to the economist

Multi-species fisheries and interactions, predator-prey, habitat, water quality, and endangered and protected resources are often considered in ecosystem-based management

The Ecosystem Principles Advisory Panel in "Ecosystem-Based Fishery Management," A Report to Congress (1999) offers that "A comprehensive ecosystem-based fisheries management approach would require managers to consider all interactions that a target fish stock has with predators, competitors, and prey species; the effects of weather and climate on fisheries biology and ecology; and the effects of fishing on fish stocks and their habitat."

And from NOAA: "An ecosystem approach to management is a geographically specified and adaptive process which (1) takes into account the ecosystem knowledge and uncertainties, (b) considers multiple external influences, and (c) strives to balance diverse societal objectives"

*** Highly Recommended Reading for Individuals Interested in the Potential Role of Economics in Ecosystem-based Management—Edwards, S. (2004) One Economist's Perspective on the Ecosystem Approach to Management. NOAA Fisheries**

The Potential Role of Economics in Ecosystems-Based Management

Many scientists view the major role of economics as being informative about economic values, or providing information about changes in economic impacts or benefits to society from different regimes of ecosystem-based management

Economics, however, has much more to offer than simply (actually a serious understatement) determining economic benefits and impacts from ecosystem-based management

The real, and perhaps most important potential role, of economics is helping to develop strategies or institutional arrangements for ecosystem-based management

Any strategy must recognize the preferences of society relative to food production, recreational opportunities, and desired states of nature and resource levels, the multiple attribute nature of the ecosystem, and risk

Recent Economic Approaches to Ecosystem-Based Management

To a large extent, economists have resorted to the literature on finance economics (e.g., portfolio selection as in Edwards, Link, and Rountree (2004), Portfolio management of wild fish stocks, Ecological Economics 49: 317-329)

Alternatively, other researchers have begun to examine the potential applicability of arbitrage theory to ecosystem-based management

Then, of course, there are the more traditional approaches—command and control, introduction of some type of private-property rights regime, co-management, and community-based management

Then, there is the possibility for combining many of the approaches (e.g., portfolio theory with private-property rights)

The Portfolio Approach

The portfolio approach is particularly appealing because it addresses two major criteria—expected returns (replace with net benefits) and risk (usually measured in terms of variance of return)

In this case, we have multiple elements (investment opportunities), each yielding different rates of return (net benefits), and each have different rates of risk (variances for each type of potential investment)

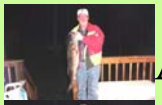
The basic problem seeks to minimize risk subject to various expected rates of return (e.g., a 15 % rate of return)—that is, we obtain information about the trade-offs between returns and risk

Although there are numerous problems with this approach, this is one major problem, when considered relative to ecosystem-based management; that is the problem of a large number of species, species attributes, and environmental and resource factors—increases the size of the variance-covariance matrix

We may not be able to obtain a solution

Many of the problems of portfolio theory can be addressed through modification of the basic problem (e.g., uncertainty, introduce downside risk, construct a factor model, maximize minimum return, and consider different variance objectives)

Arbitrage



Arbitrage price theory is another type of portfolio model

It seeks to derive the required rates of return on risky assets based on the assets systematic relationship to several risk factors

It differs from the standard portfolio theory by explicitly allowing for multiple risks

It has not apparently been applied to fisheries, but it has been applied to forest ecosystems

OK! A Rehash of Issues

- Ecosystem-based management is perceived as being necessary because society is likely to derive large net benefits
- This is because ecosystem-based management addresses more resources than traditional single and multi-species management regimes
- An attempt is being made to optimize relative to the entire ecosystem complex and not just one or a few species or user groups
- But there are a lot of problems!

Ecosystem-Based Management and Some Problems

Basic Problem—inadequate information and uncertainty relative to species interactions, effects of fishing and other uses of the environment on ecosystems, stock definitions or boundaries, the food web, habitat needs, and economic values of an ecosystem and its components

Alternatively, we have inadequate scientific, economic, and social data relative to ecosystem states and dynamics

WE still have the age old problem—what is the economic value to society of enhancing submerged aquatic vegetation, maintaining or restoring essential fish habitat, protecting prey species, enhancing water quality, and so on?

OK! Everybody knows about the problems

We, nevertheless, have to move forward

Some Alternative Emerging Methods for Assessing Economic Values

Commencing with Costanza et al. (1997) "The value of the world's ecosystem services and natural capital," Nature 387: 253-260, there has been a major international research effort to determine the economic value of the services of an ecosystem

Moreover, there has been an increasing criticism of most conventional approaches (e.g., willingness to pay, willingness to accept, stated preference (contingent valuation), neoclassical theory, production function analysis, replacement/restoration cost technique, travel cost method, welfare economics (CBA), and hedonic pricing)

Chee (2004) "An ecological perspective on the valuation of ecosystem services," Biological Conservation, 120: 549-565, provides a comprehensive overview and criticism of the traditional methods used by economists to value ecosystem services

Despite being an extremely comprehensive and interesting article, there are some serious deficiencies or errors in the work (e.g., existence of markets; welfare economics being restricted to cost-benefit analysis; the assumption that the production function approach is restricted to the role of ecosystem services in providing only marketable goods and services; and the assumption that hedonic pricing strategies cannot be combined with educational information about relevant environmental variables)

Bottom Line

Despite the problems with the conventional economic valuation techniques, they should not be discarded or viewed as inadequate for valuing ecosystem services

Modifications of the existing approaches have been developed to ensure that individuals are educated about the role of ecosystem services; that there is appropriate stakeholder input into the decision process; and that uncertainty is better incorporated into the estimation and evaluation process

A common criticism of the traditional approaches is that they fail to recognize multiple criteria and constraints; this can be easily overcome through the use of multiple objective analysis, which has been applied to a wide array of problems involving economic valuation

One thing is sure: economists do have their work cut out for them relative to valuing ecosystem services

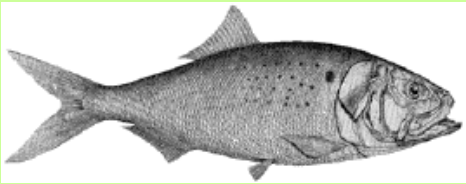
Not Necessarily the Last Say, but Lets Close the Issue about Best Valuation Method

de Groot, Wilson, and Boumans (2002), "Typology for the classification, description, and valuation of ecosystem functions, goods and services," Ecological Economics, 41: 393-408 provide an excellent overview on options for valuing ecosystem services

They correctly conclude that although several valuation methods can be used, ideally a type of rank ordering should be developed to determine the most preferred valuation method

This could easily be accomplished by convening a panel of experts to aid in determining the most appropriate valuation method relative to the ecosystem under consideration

The Real Agenda: Menhaden



Atlantic menhaden (*Brevoortia tyrannus*) is one of the more important commercial and ecological species of the Chesapeake Bay

Spawning is between March and May and occurs off the shelf waters

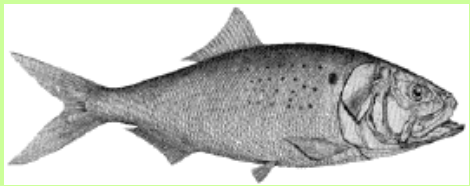
Sexual maturity is just prior to age three

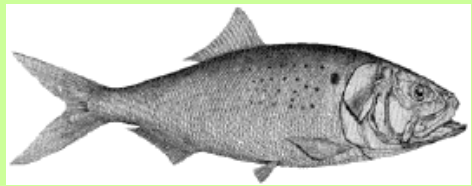
Menhaden reach a maximum size of about 15 inches, and they feed on both phytoplankton and zooplankton

Annual landings were typically between 300,000 and 400,000 metric tons—110,400 (for past seven years)

The fish are landed for the value as meal, oil and bait, but health care products (omega 3) have become a major product (margarine in the US will soon follow—approved in 1997 by FDA)

It is recognized as a major filter feeder, which contributes to water quality, and as prey for striped bass, bluefish, and weakfish (all important recreational, as well as commercial, species) in the region (also sharks and tuna)





Management

- **The Atlantic States Marine Fisheries Commission has regulatory authority for Menhaden; each state, however, imposes their own regulations**
- **Regulations involve spatial and temporal restrictions, limits on bycatch, and use of gear**
- **Maryland prohibits the use of purse seine vessels (the primary gear) and spotter aircraft; Virginia allows a purse seine fishery**
- **Only the states of Virginia and North Carolina allow industrialized menhaden fishing, which accounts for about 75% of Atlantic menhaden landings (From Brame, Duval, Goldsborough, Hinman, and Schick (2004), "Menhaden Matter: Proactive Conservations Measures are Needed Now to Protect the Ecological Role of Atlantic Menhaden in the Chesapeake Bay"**
- **There is no overall quota—changed 02/09/05**

A Call to Arms: Ecosystem-based Management

A consortium of NGOs and scientists expressed concern about declining water quality, gamefish populations and conditions, and stressed marine birds in the Bay region

The Atlantic States Marine Fisheries Commission held a workshop to examine the status of menhaden with respect to its ecological role; the purpose of which was to assess the feasibility of ecosystem based management relative to the perceived role of menhaden

Some General Concerns For Developing Ecosystem-Based Management

The fishery is one of the oldest fisheries in the nation; there are only two major firms; and there are approximately 12 purse seine vessels

And yet, the information for ecosystem-based management is extremely sparse

Do not know the abundance of menhaden in the Chesapeake Bay or whether or not there has been localized depletion

No quantitative analysis of the ecological role of menhaden

May be a possibility of a link between striped bass disease and abundance, but this is not really known

Menhaden productivity depends on and impacts water quality, but the direct relationships are not known

Biological reference points for the Bay are not know

Proportion of age zeros and ones in the Bay is unknown

Striped bass, weakfish, and bluefish feed on menhaden, but it has been found that, at least, striped bass realize the same weight and growth feeding on other prey

Striped bass consume nearly 50% (57 % based on bioenergetic work) of the commercial harvest

OK! We Have Some Serious Unknowns!


But an ecosystem-based management strategy will go forward


Primarily a multi-species plan, which will address the populations, age structure, etc. of menhaden, striped bass, weakfish, and bluefish


Regulations or management will primarily be with respect to the commercial fishery (maybe some restrictions on recreational fishery)


No real discussion about managing other agents affecting the population of menhaden or the ecosystem (e.g., agricultural runoff and TBT on the hulls of naval vessels)


Reference points, particularly considering socio-economic factors, need to be developed

A Little Chaos and Confusion! Just A Little!

Where is economics going to come in?

Restricting attention to the four species, economic valuation may not be all that difficult

Relatively good procedures (travel cost and RUM models) for estimating the economic value of the recreational fisheries for striped bass, weakfish, and bluefish

Pretty much straightforward approach for estimating the economic values of the commercial fisheries (synthetic inverse demand models or flexible demand models, such as AIDS and other)

Menhaden poses a bit of problem because vessels are not profit centers and ex-vessel prices are used primarily as an accounting device to reward skipper and crew

Using data available from the menhaden companies, however, should be sufficient to estimate consumer and producer benefits or net benefits of the menhaden fishery

Maybe It is Not So Straightforward!

- **We should be able to assess the economic values of the commercial and recreational fisheries using conventional metrics**
- **But then, there is the overriding issue of the ecosystem services of menhaden—water quality, prey, etc.**
- **The potential effects of menhaden abundance on water quality may be very difficult to assess—the populations of oysters, a major filter feeder, has dramatically declined; there has been a large scale reduction in submerged aquatic vegetation; etc.**
- **The assessment of the economic value of menhaden as prey might be conducted via a production function approach—considers the contribution an ecosystem service makes to the production of some marketed/marketable good or service**
- **The production function approach would require relating growth and resource levels of the three species to the resource levels and availability of menhaden**
- **Then, of course, there is the stated preference approach and contingent valuation**
- **And the Damage Schedule Approach**

An Emerging Technique

Data envelopment analysis, using directional distance vectors rather than conventional input or output distance functions, has been used to estimate the shadow value of different states of ecosystems relative to salmon farming in Norway—huh!

This is the benefit function, which was introduced by Luenberger (1992), "Benefit Functions and Duality," Journal of Mathematical Economics, 21: 461-481

It provides a tool for well-defined cardinal comparisons of different bundles of goods and services

It also provides a way to address externalities (using a social rather than private benefit function)—Luenberger, D.A. (1995), "Externalities and Benefits," Journal of Mathematical Economics 24: 159-177

Closing It Down

At the present time, other than realizing a need to consider menhaden as prey, management authorities do not appear to have any preconceived notions about management—except an overall TAC and quota, which equate to a reduction in landings

The economic valuation work should be done, but it is likely that management will be based mostly on scientific issues

Economic valuation, however, should proceed with what can actually be done—commercial and recreational fisheries

A panel of experts (interdisciplinary approach) should be convened to determine the most appropriate valuation method and the ecosystem services to be evaluated

Institutional structures should be identified and assessed relative to their potential feasibility

February 9, 2005—Atlantic States Marine Fisheries Commission imposed a temporary 110,400 mt. quota on the fishery, until an ecosystem plan is developed. Virginia protested the quota!